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GE AND GROWTH OF IMMATURE ROSEFISH *SEBASTES MARINUS*) IN THE GULF OF MAINE AND OFF WESTERN NOVA SCOTIA

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ABSTRACT

From examination of the opercular bones, otoliths, and scales of rosefish (*Sebastes marinus*) it was learned that scales would be the most useful in determining the age and growth of this species. The region covered by the tip of the pectoral fin and immediately posterior to it and adjacent to the lateral line contained the largest and most uniformly shaped scales with the highest circulus count, and all scale samples were, therefore, taken from this part of the body. Only scales from fish less than 235 mm. long, measured from the tip of the snout to the fork of the tail, were read, as "size-at-maturity" studies have proved these to be primarily immature fish. "Year band" formation starts in April of one year and extends through March of the next year. There is some indication that scales do not form until the spring following the year of birth, necessitating the addition of one year to the total age as shown on the scale to determine the calendar year of birth.

Two methods of calculating estimated length at various annuli gave similar results when applied to the same data. Variations in fish length—scale radius relationship at different seasons of the year and from one biological area to another appear to be small and do not greatly affect the calculated length values obtained. Both in the Gulf of Maine and off the Browns Bank area of western Nova Scotia the rosefish appear to grow very slowly in comparison with other important commercial species. In the Gulf of Maine, the average size of rosefish at annulus 1 is 52 mm.; annulus 2, 76 mm.; annulus 3, 99 mm.; annulus 4, 121 mm.; annulus 5, 139 mm.; annulus 6, 154 mm.; annulus 7, 169 mm.; annulus 8, 189 mm.; and annulus 9, 218 mm. Very similar results were obtained for fish from Browns Bank area of western Nova Scotia. The rate of growth, computed by averaging the differences between the calculated lengths of individual fish at each annulus, was less than 25 mm. a year to the ninth annulus both in the Gulf of Maine and off Browns Bank.

GE AND GROWTH OF IMMATURE ROSEFISH (*SEBASTES MARINUS*) IN THE GULF OF MAINE AND OFF WESTERN NOVA SCOTIA

he rosefish (*Sebastes marinus*) [1] is abundant on fishing banks of the Gulf of Maine and Nova ia in depths ranging from 50 to 120 fathoms. l 1935, rosefish were marketable only in limited ntities, and the yearly landings were well under 0,000 pounds. Technological advances in han- fish, particularly filleting, quick-freezing, and perfection of an automatic scaling machine, in tion to the development of markets in Mid- ern States, stimulated a rapid increase in the ish fishery to an average yearly catch of more 100,000,000 pounds. The catch reached a peak 946 of 178,000,000 pounds. As a result of the ing importance of the fishery, the Fish and Wild- ervice began a study of the rosefish in the fall 942. This report summarizes one phase of the tigation; namely, the age and growth of im- re rosefish in the Gulf of Maine and off the ns Bank area of western Nova Scotia.

PREPARATION AND STUDY OF MATERIALS

STRUCTURES EXAMINED

om a preliminary examination of the bony struc- of the rosefish it was found that the opercular , otoliths, and scales showed series of sculp- gs, which, on the basis of previous age studies her species of fish, were suggestive of year marks. the opercular bone and the otolith proved lt to use in age analysis. In the opercular the markings on some specimens were indis- or were marred by a cavernous development the base of the bone (fig. 1). The otoliths red more promising for determining the age of osefish. Freshly recovered otoliths or dried mens cleared slightly in oil of cloves, oil of rgreen, or glycerine, showed dark and light , as did cross sections of dry otoliths (figs. 2). Otoliths from the larger fish had a greater number of bands, but the individual rings were close together and less distinct. Because of the difficulty in collecting and preparing otoliths, and in distinguishing bands in the larger fish, together with the fact that only age data and no growth data could be obtained from otoliths, the study of them was discontinued. Attention was focused on the scales as a method of determining age and growth in rosefish.

Rosefish scales are oblong and strongly ctenoid on their outer edge, the number of rows of cteni being

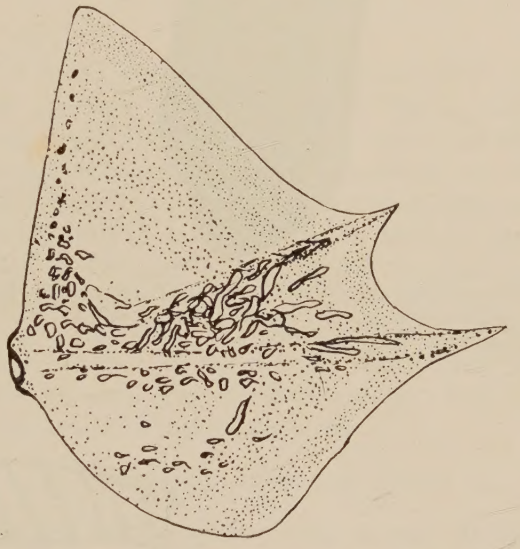


FIGURE 1.—Opercular bone showing growth bands. From a female rosefish 160 mm. long taken in the Gulf of Maine, January 1945. Enlarged 4 times.

FIGURE 2.—Otolith showing growth bands. From a male rosefish 144 mm. long taken in the Gulf of Maine, November 1942. Enlarged 6 times.

tes marinus in American waters does not grow so large as its counterpart pean waters. The largest fish we have recorded in the Gulf of Maine n. from the tip of the snout to the fork of the tail. Preliminary taxonomic on of recently collected data on the American fish with published data uropean fish indicates extensive variations of the genus throughout its d the need for a complete taxonomic study.

greater on the scales of larger fish. Radii extend from the focus to the anterior margin of the scale and are more numerous in the larger than in the smaller fish. The circuli are distributed in bands of different spacings, and a band of wide-spaced circuli is generally followed by a band of narrow-spaced circuli.

FIGURE 3.—Cross section of an otolith showing growth bands. From a female rosefish 70 mm. long taken in the Gulf of Maine, August 1943. Enlarged 30 times.

AREA OF FISH FROM WHICH SCALE SAMPL WERE TAKEN

To determine the region on the body of the ro fish from which scales should be collected, the bo was arbitrarily divided into 16 areas (fig. 4). Sca were taken from the midpoint of each of these ar and compared as to relative size, regularity, a circulus count. Four fish were examined in t manner. It was found that areas 11 and 13, region covered by the tip of the pectoral fin a immediately posterior to it and adjacent to lateral line, had the largest and most uniform shaped scales with the highest circulus count (ta 1). The relatively larger and more uniformly sha scales from the "pectoral patch" were easier mount and measure than scales from other part the body. Also, since scales from the "pecto patch" area have the highest circulus count, it most likely that they show maximum growth fr the beginning of scale formation. All scale sam in the present study were taken from the "pecto patch."

COLLECTION OF SCALE DATA

Scale collections were obtained from random of fish taken from individual trips of rosefish dragg In each case, the boat captain was interviewed

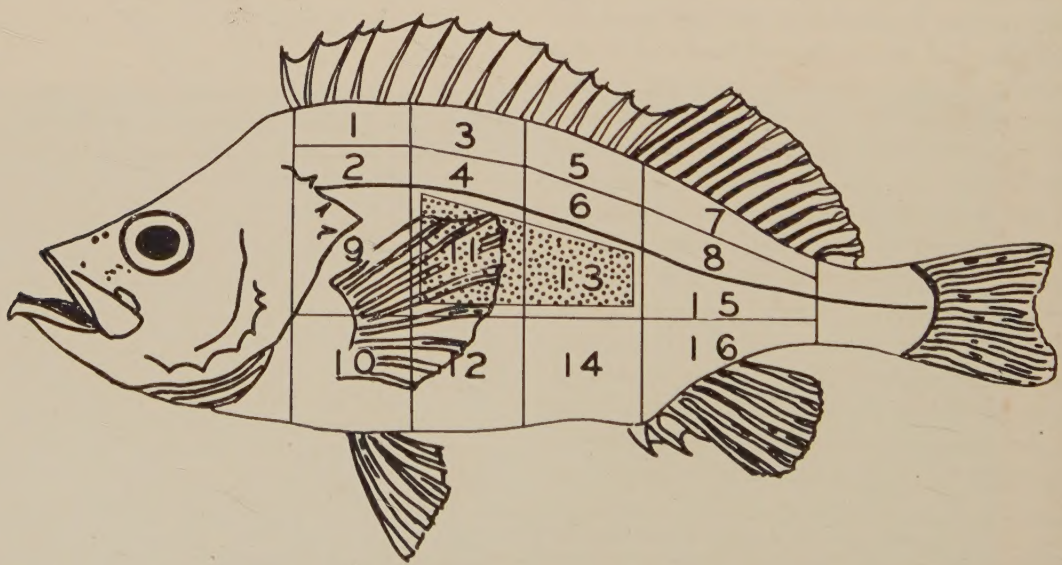


FIGURE 4.—Numbers indicate areas from which scales were removed for examination and study. The darkened patch on areas 11 a is referred to in the text as the "pectoral patch."

TABLE 1.—*Circulus counts and anterior radii of rosefish scales from various body areas*

Area	Circulus count, Specimen				Area	Anterior radius [1], Specimen			
	1 [2]	2 [3]	3 [4]	4 [5]		1 [2]	2 [3]	3 [4]	4 [5]
----------	80	56	78	143	1----------	118	77	122	210
----------	108	76	129	164	2----------	205	110	239	261
----------	84	82	84	139	3----------	142	113	132	197
----------	94	98	105	208	4----------	149	166	195	383
----------	97	88	94	164	5----------	166	118	148	246
----------	105	113	102	195	6----------	207	180	192	351
----------	88	77	89	173	7----------	149	116	140	262
----------	101	95	143	191	8----------	196	139	270	340
----------	98	114	129	223	9----------	264	198	267	455
----------	105	106	112	228	10----------	241	200	160	427
----------	125	120	146	250	11----------	282	230	314	468
----------	106	106	123	231	12----------	227	178	242	461
----------	117	125	144	253	13----------	261	220	297	509
----------	112	108	138	237	14----------	227	195	266	438
----------	111	115	142	244	15----------	230	217	286	445
----------	110	110	122	196	16----------	225	173	220	353

[1] In millimeters, magnified 100 times.
[2] Male, 174 mm., Jeffreys Ledge, January 1943.
[3] Male, 154 mm., Jeffreys Ledge, January 1945.
[4] Female, 198 mm., Cashes, October 1943.
[5] Female, 304 mm., Cashes, October 1943.

orted fishing in only one biological area.[2] Only se "pure" trips were sampled in order to obtain hogeneous data from each area. The length of fish was measured to the nearest millimeter by ns of a measuring board.[3] These samples have n continuously collected since August 1942. ly in 1943, it was noticed that random sampling he commercial catch resulted in few samples of es from fish under 200 mm. in length. To obtain e adequate sampling of the fish in this size gory, scale collections were taken from as many under 200 mm. as could be procured.

PARATION AND METHOD OF EXAMINING SCALE SAMPLES

cales were mounted in corn syrup, or glycerine–tin, or dry, on glass slides, or were impressed on iloid, depending on the size of the scale. Clearest nts were obtained of the smaller scales, either dry, fter alizarin staining, in the liquid media. The er scales were more easily handled as celluloid ressions. Each slide was given a code number. a on size, sex, and locality were omitted from label to prevent their influencing the investi- rs in determining the age readings.

All scales were read using a modification of the scale projector described by Van Oosten, Deason, and Jobes (1934). The machine was calibrated to produce an image 99.6 to 100.6 times the size of the object projected. Scale measurements used in the present analysis were based on an average magnification of 100 times. The projected image of the scale was measured along the median radius from the center of the focus to each annulus and to the anterior margin of the scale by marking off these distances on a strip of cardboard and then measuring them with a millimeter rule.

EXAMINATION OF SCALE MATERIAL

On the basis of scale studies on other species of fishes (Van Oosten 1929; Graham 1929), it is to be expected that the circulus bands present on rosefish scales represent periods of seasonal growth, a band of wide-spaced circuli being presumably the fast growth during summer, and a band of narrow-spaced circuli the slow growth in winter. Exploratory examination of the scales from all sizes of fish showed that the summer and winter bands were broad and could be most readily distinguished in fish less than approximately 235 mm. in length, but were narrow and difficult to determine with certainty for larger fish.

It was not possible to undertake a study of the age and growth of all sizes of rosefish because of limitations in facilities. Therefore, our study was confined to fish under 235 mm. in length. Size-at-maturity studies showed fish in this size category to be mainly

om a study of the degree of infestation of rosefish with the copepod para- *phyrion lumpi*) and information on the life history of the parasite, plus ination of centers of fishing concentration and the size composition of ch at these places, the rosefish stock was subdivided into population units, closed in various biological areas as follows: Mount Desert-Matinicus; gan-Jeffreys-Platts; East of Gloucester-Highlands; Channel; Cigar Cashes; and Browns Bank (fig. 5).

less otherwise specified, all measurements of rosefish are from the tip of ut to the fork of the tail.

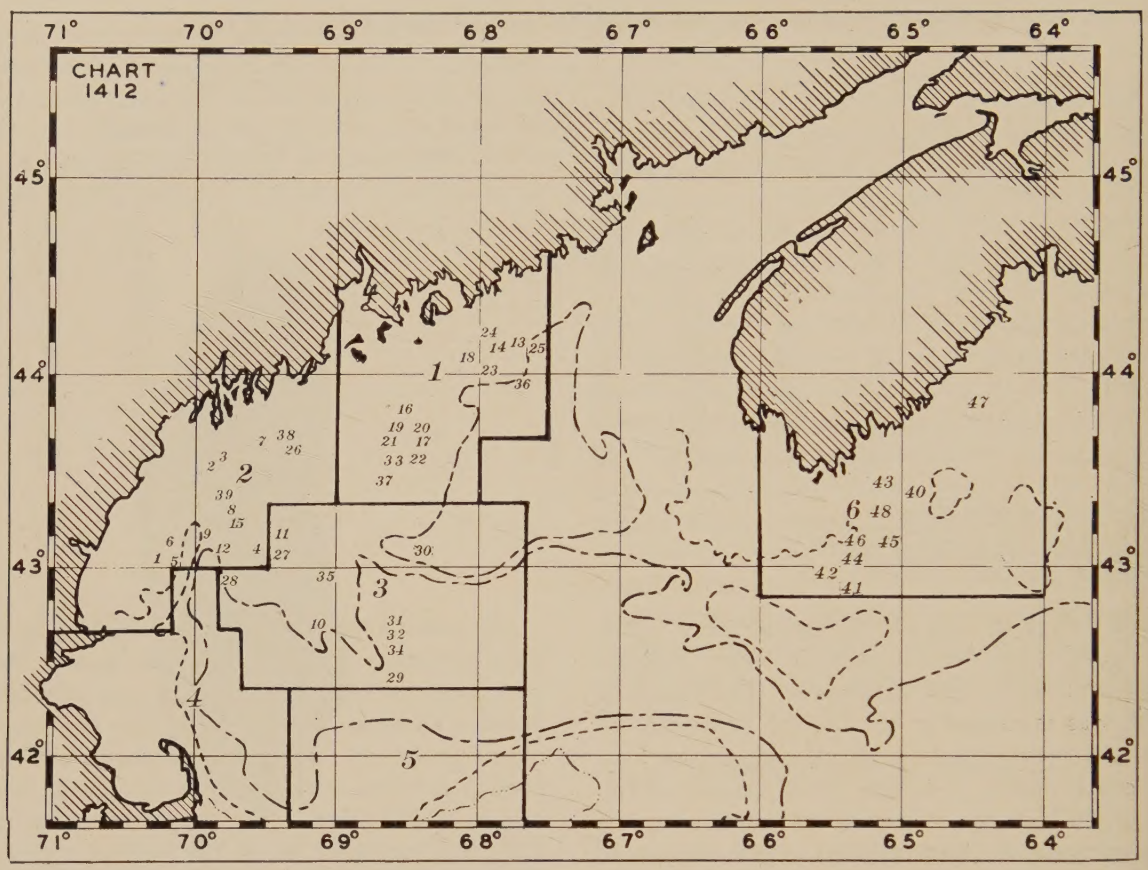


FIGURE 5.—Fishing concentration areas from which samples were obtained: area 1, Mount Desert-Matinicus; area 2, Monhegan-Jeffr Platts; area 3, Cigar Ridge-Cashes; area 6, Browns Bank area of western Nova Scotia (table 2). No collections of immature were obtained from area 4, east of Gloucester-Highlands, or from area 5, Channel, for the period studied.

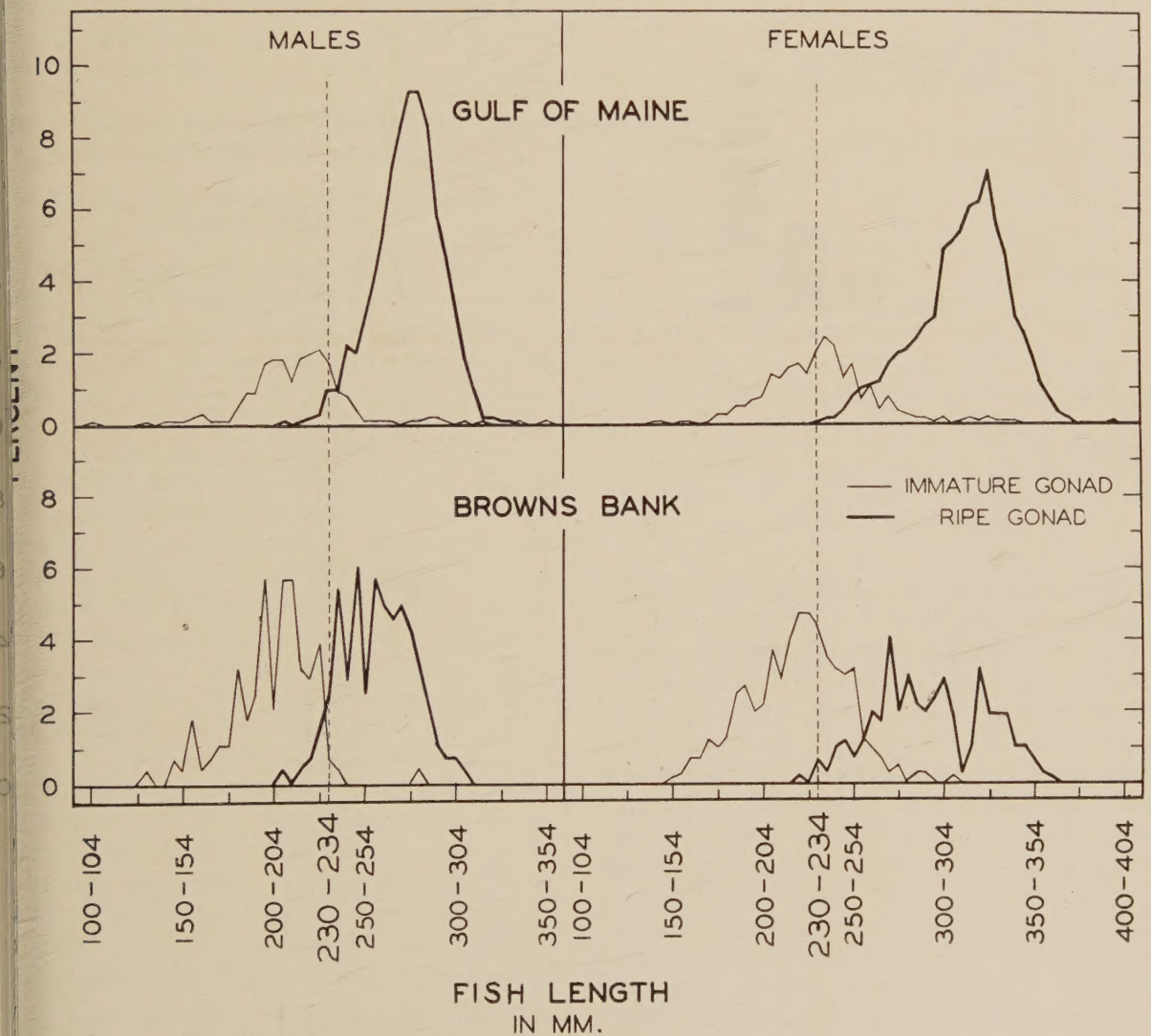
TABLE 2.—*Collections used in the study of the age and growth of immature rosefish*

Collection No.	Year	Date landed	Area [1]	Number of fish	Collection No.	Year	Date landed	Area [1]	Num of f
1	1942	Sept. 14	2	15	25	1944	June 17	1	
2	1942	Oct. 16	2	5	26	1944	June 19	2	
3	1942	Oct. 22	2	27	27	1944	July 1	3	
4	1942	Nov. 3	2	34	28	1944	Aug. 21	3	
5	1942	Dec. 15	2	5	29	1944	Aug. 26	3	
6	1943	Feb. 11	2	37	30	1944	Aug. 28	3	
7	1943	Mar. 20	2	6	31	1944	Oct. 10	3	
8	1943	Mar. 29	2	3	32	1944	Oct. 13	3	
9	1943	May 26	2	1	33	1944	Oct. 26	1	
10	1943	May 28	3	9	34	1944	Oct. 27	3	
11	1943	June 14	3	21	35	1944	Nov. 14	3	
12	1943	June 15	2	1	36	1944	Nov. 22	1	
13	1943	July 30	1	6	37	1944	Dec. 4	1	
14	1943	Aug. 6	1	2	38	1944	Dec. 5	2	
15	1943	Aug. 13	2	21	39	1944	Dec. 16	2	
16	1943	Aug. 13	1	9	40	1942	Dec. 11	6	
17	1943	Aug. 15	1	24	41	1943	Mar. 17	6	
18	1943	Aug. 16	1	43	42	1943	Apr. 9	6	
19	1942	Oct. 9	1	17	43	1943	June 4	6	
20	1942	Oct. 29	1	8	44	1943	June 7	6	
21	1942	Nov. 12	1	9	45	1943	June 8	6	
22	1942	Nov. 20	1	8	46	1943	June 14	6	
23	1942	Nov. 9	1	1	47	1943	Aug. 17	6	
24	1942	Dec. 10	1	29	48	1943	Dec. 23	6	

[1] Area 1 is the Mount Desert-Matinicus region; area 2, the Monhegan-Jeffreys-Platts region; area 3, the Cashes region; area 6, the Browns Bank region. See for a demarcation of these regions and the location of each collection point.

nature. For example, in 1943 and 1944 in the Gulf Maine, 92 percent of the males and 99 percent of females less than 235 mm. in length were imma-, while in the Browns Bank area, 88 percent of males and 98 percent of the females under 235 . were immature. The relatively few mature fish w 235 mm. were mostly in the size range from to 234 mm., as shown in figure 6.

cale samples obtained from random lots of the h of the rosefish fleet included comparatively few fish below 235 mm. in length, especially from e under 200 mm. To obtain a large amount of e data for fish under 200 mm., scales were taken from as many fish in this size category as possible. Despite inclusion of the selected scale samples from the smaller fish, the total number of scale samples for fish under 235 mm. that could be procured from the commercial catch was relatively small. In the Gulf of Maine region, 158 scale samples were collected in 1942, 183 in 1943, and 65 in 1944, and these could only be obtained from fish in areas 1, 2, and 3, the Mount Desert-Matinicus, Monhegan-Jeffreys-Platts, and Cigar Ridge-Cashes areas, respectively. In the Browns Bank area off western Nova Scotia, 20 scale samples were collected in 1942 and 91 in 1943 (tables 2 and 3, and fig. 5).



E 6.—Length-frequency distributions of immature fish by sex for the Gulf of Maine and the Browns Bank area. Gulf of Maine data: males examined in 1943 and 1944, 3,372; males examined in 1944, 1,644. Browns Bank data: females examined in 1943 and 1944, 91; males examined in 1944, 280.

TABLE 3.—*Length-frequency distribution of each collection of immature rosefish taken in the Gulf of Maine from September 1942 through December 1944 and in the Browns Bank area of western Nova Scotia December 1942 through December 1943*

| Fish length in millimeters | Collection No.[1] | | |

Fishing selectivity largely accounts for the small mbers of fish less than 235 mm. found in the com- rcial catch and is due to the fact that rosefish less n 8 inches long (200 mm.) are not marketable at oucester. Consequently, the fishermen avoid con- trations of small fish. In most instances, this is difficult, as there appears to be a definite segrega- n of the smaller or immature fish, from the larger mature fish. Under normal conditions when small are inadvertently captured, they are culled and own overboard at sea. It is apparent, then, that ge numbers of scale samples from small fish can t be procured by means of an experimental vessel ing in the nursery areas. Pending such collection, vas deemed advisable to study the available data obtain preliminary information on the age and wth of the rosefish.

ROCEDURE FOR DETERMINING AGE AND GROWTH FROM SCALES

SIGNIFICANCE OF CIRCULUS BANDS ON ROSEFISH SCALES

n the basis of scale studies on other species of es, it is to be expected that the circulus bands ent on the rosefish scale represent periods of onal growth. To test this hypothesis a study made of the scales of 229 fish less than 225 mm. ength taken in the Gulf of Maine in the period n April 1942 through June 1943. The part of scale from the last circulus in the last band of ow-spaced circuli to the edge of the scale was gnated the "terminal-zone." It was observed all specimens had only wide-spaced circuli in zone in April through May 1942. By November , the marginal circuli of the zone were closer ther in some specimens and, in February 1943, ost specimens. By April 1943, all the circuli he terminal-zone were once again widely sep- ed.[4] Furthermore, the circulus count and size e terminal-zone increased from April–May 1942 February–March 1943, when there was an pt decrease in these characters in a few of the and by April 1943, in all of the fish (fig. 7, 4). The sudden decrease in the circulus count in the size of the terminal-zone in April 1943 be explained by the completion of the band of

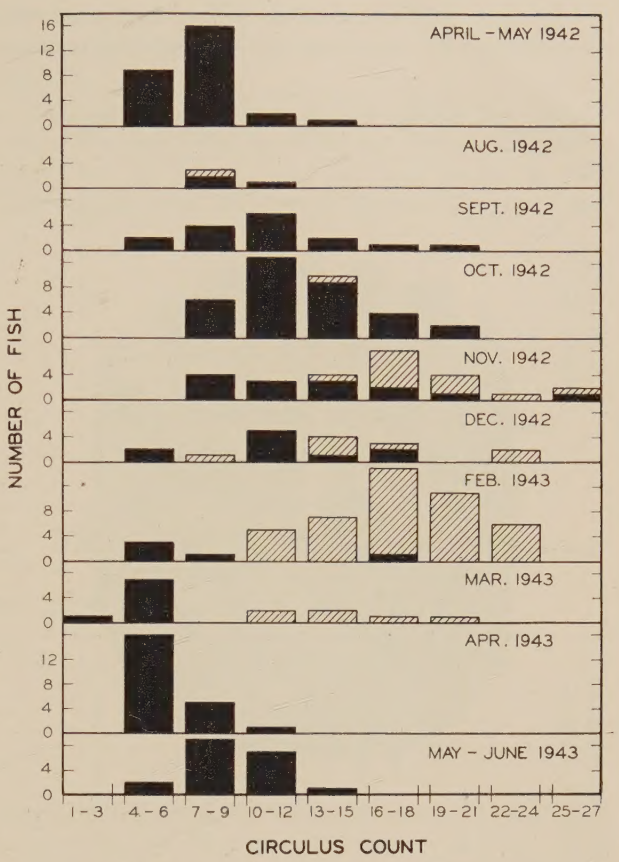


FIGURE 7.—Circulus counts from the last band of narrow-spaced circuli to the edge of the scale (terminal-zone) for scales collected from rosefish less than 225 mm. in length taken in the Gulf of Maine from April 1942 through June 1943. The solid bars indicate wide-spaced circuli, and the diagonal lines narrow-spaced circuli at the edge of the terminal-zone.

narrow-spaced circuli ending another year's growth and the inception of a new band of wide-spaced circuli starting the next year's growth.

From these data it can be seen that the narrow-spaced and wide-spaced circulus bands on the rosefish scale, as on the scales of other fishes, denote seasonal growth intervals. During April through October, growth is most rapid and a band of wide-spaced circuli is formed. From November through March, growth slows down and a band of narrow-spaced circuli results. The narrow-spaced band of circuli is considered the annular band or annulus. In the annular band, the circuli do not continue posteriorly along the lateral margins of the scale as they do in the band of wide-spaced circuli, but instead, most of them end abruptly or merge at the lateral margin of the scale forming a characteristic broken pattern. Examples of scales with varying

nds of wide-spaced and narrow-spaced circuli are readily distinguishable ach other upon examination. Nevertheless, a more objective method of iating between wide- and narrow-spaced circuli was attempted by caliper ements of circuli widths. Physical limitations in our apparatus plus inherent limitations in the material caused us to discontinue this tech-

TABLE 4.—*Time of formation of narrow and wide bands in rosefish less than 225 mm. in fish length*

Number of circuli [1]	Number of fish																			
	April–May 1942		August 1942		September 1942		October 1942		November 1942		December 1942		February 1943		March 1943		April 1943		May–J 1943	
	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	r
1–3															1					
4–6	9				2						2		3		7		16		2	
7–9	16		2	1	4		6		4			1	1				5		9	
10–12	2		1		6		13		3		5			5		2	1		7	
13–15	1				2		9	1	3	1	1	3		7		2			1	
16–18					1		4		2	6	2	1	1	14		1				
19–21					1		2		1	3				11		1				
22–24										1		2		6						
25–27									1	1										
28–30																				
Total	28		3	1	16		34	1	14	12	10	7	5	43	8	6	22		19	

Zone growth [4]	Number of fish																			
	April–May 1942		August 1942		September 1942		October 1942		November 1942		December 1942		February 1943		March 1943		April 1943		May–J 1943	
	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	Narrow [3]	Wide [2]	r
0–4																				
5–9	1			1	1						1	1			2		3			
10–14	6				1		1		1		1		3		6		10			
15–19	14		2		1		4		2				1				6		4	
20–24	4				6		5		4					2		2	2		6	
25–29			1		1		10		2	1	2	1		3		1			7	
30–34	2				3		7	1		1	3	1		6		2	1		2	
35–39	1						3		1	1	1	2		12						
40–44					2		3		2	5			1	9		1				
45–49					1					2	2			2						
50–54							1							5						
55–59									2	2		1		1						
60–64												1		2						
65–69														1						
70–74																				
Total	28		3	1	16		34	1	14	12	10	7	5	43	8	6	22		19	

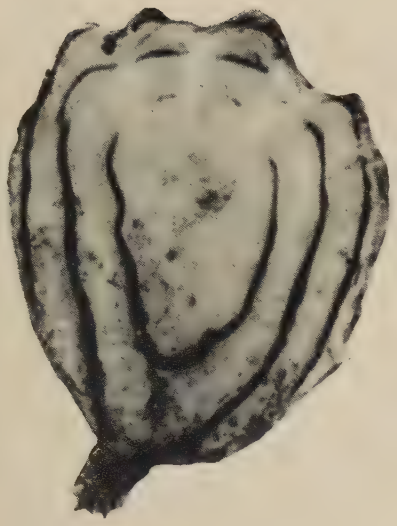
[1] Number of circuli from the edge of the last band of narrow-spaced circuli to the scale margin.
[2] Wide phase; wide-spaced circuli only.
[3] Narrow phase; wide-spaced circuli followed by narrow-spaced circuli at the scale margin.
[4] The median radial distance in millimeters from the edge of the last band of narrow-spaced circuli to the scale margin, magnified 100 times.

numbers of annuli are shown in figures 8 through 15. Figures 8 and 9 are scales from fish 30 and 50 mm. in length, respectively, which were captured in October. They show no annuli but consist entirely of wide-spaced circuli. Figure 10, a scale from a fish 59 mm. in length, has one annulus, and figures 11 through 15 contain two, three, four, six, and eight annuli, respectively.

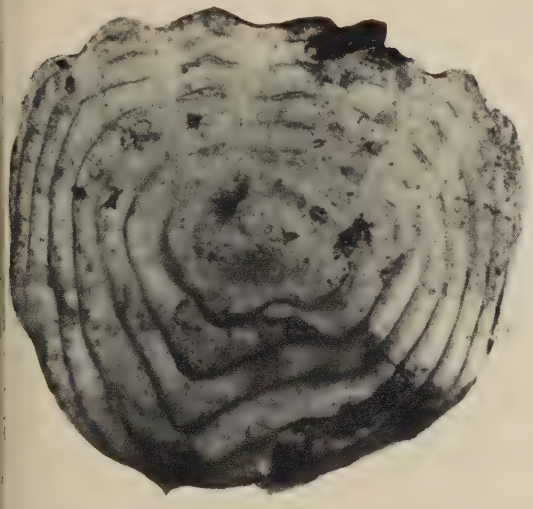
AGE OF ROSEFISH AT TIME OF SCALE FORMATION

Although scale readings give the age of the rosefish from inception of the scale to the time of capture, they do not furnish any information on the extent of the period preceding initial scale formation. The rosefish is ovoviviparous, and from a study of the relative frequency of various developmental stages of the embryos contained in the ovaries of the fish throughout the spring and summer, it found that the Gulf of Maine rosefish extrude young from mid-May through early September, v the peak birth period in July. The size at birt indicated by larvae taken from a 297-mm. fish cau in the Mount Desert-Matinicus area in August 1 These larvae still retained the yolk sac but sw actively when placed in a container of salt wa A sample of the specimens ranged from 7.1 to mm. in total length. Our findings on the rosefis Gulf of Maine waters confirm those of Bigelow Welsh (1925:308) and are also in agreement v those of Frost (1938:15) in Newfoundland wat which suggest a similar rosefish birth period in b areas.

According to Bigelow and Welsh (1925:311, 147) rosefish larvae 20 mm. in length do not h scales. Therefore, in order for newly born la



URE 8.—Scale showing only four wide-spaced circuli, no annuli, rom a fish 30 mm. long captured in the Cigar Ridge-Cashes ea, October 1946.



RE 9.—Scale showing only eight wide-spaced circuli, no nuli, from a fish 50 mm. in length captured in the Mount sert-Matinicus area, October 1944.

how the first annular ring in April of the follow- year, they must grow longer than 20 mm. by fall of the year in which they are born so that a s of wide-spaced circuli can be formed. Infor- ion on the growth of larval rosefish on the Gulf Maine or Nova Scotian fishing grounds is not lable but is indicated by data obtained from foundland grounds. During cruises of the re- ch vessel *Cape Agulhas* in Newfoundland waters he spring and summer of 1932 to 1935, a large s of rosefish larvae were taken, chiefly by plankton nets.[5] The lengths of these larvae are summarized by months and years of collection in table 5.

An examination of these data shows that for all years combined the mode of the length frequency was 7 mm. in May, 8 mm. in June, 9 mm. in July and August, and 10 mm. in September, indicating

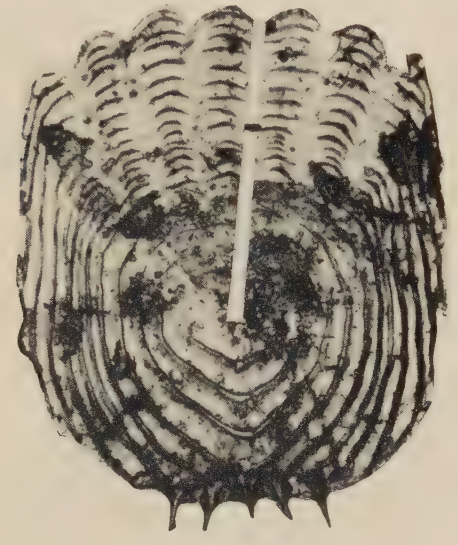


FIGURE 10.—Scale showing one annulus and initial formation of the wide-spaced circuli band of the second year band. From 59-mm. male captured in the Monhegan-Jeffreys-Platts area, April 1946.

FIGURE 11.—Scale showing two annuli and initial formation of the wide-spaced circuli band of the third year band. From a female 102 mm. long, captured in the Monhegan-Jeffreys-Platts area, June 1946.

[5] The general area of capture for these fish is shown in a paper by Frost (1938). A copy of the original length data was made available by the Newfoundland Department of Natural Resources through the courtesy of the director Dr. Wilfred Templeman.

extremely slow growth. In May at the beginning of the birth period, two fish, 20 and 21 mm. in length, were also taken. According to the growth data, these fish could not have reached so large a size if they had been born in April or May of the year in which they were captured. They must have been born in the previous year because fish of this size do not have scales.

FIGURE 12.—Scale showing three annuli. From a male, 122 mm. long, captured east of Gloucester-Highlands area, March 1946.

FIGURE 13.—Scale showing four annuli. From a female, 144 mm. long, captured in the Monhegan-Jeffreys-Platts area, April 1946.

FIGURE 14.—Scale showing six annuli. From a male, 159 m long, captured in the Browns Bank area, May 1946.

FIGURE 15.—Scale showing eight annuli. From a male, 234 m long, captured in the Monhegan-Jeffreys-Platts area, April 19

Rosefish, 37 to 55 mm. in total length, obtained the Gulf of Maine in October of 1944 [6] and 194 show scales having a band of wide-spaced circuli a a few narrow-spaced circuli. The scales must ha formed when the fish were more than 20 mm. a less than 37 mm. in length and, apparently, dur the year in which the fish were captured. On

[6] Five fish, 50–55 mm. long, taken in the Mount Desert-Matinicus area.
[7] Six fish, 37–51 mm. long, taken in the Cigar Ridge-Cashes area.

TABLE 5.—*Lengths of larval rosefish taken in Newfoundland waters* [1]

Larva length in millimeters	May	June				July			August					September				All years				
	1932	1932	1933	1934	1935	1933	1934	1935	1931	1932	1933	1934	1935	1931	1932	1933	1935	May	June	July	August	September
	1	1						1										1	1	1		
	7		11	1			1	1	16		1					1		7	12	2	17	1
	23	3	28	21	2	1	15	5	33					1			1	23	54	21	33	2
	5		75	34	23	16	20	4	27	2		1		1		1		5	132	40	30	2
			20	16	3	24	6	12	53	1	3		2		1		1		39	42	59	2
				5		4	1	6	41	1	2		3	1	2				5	11	47	3
	1	1		1					10	1			1		1			1	2		12	1
	1	1	1	1					1									1	3		1	
				1					1			2							1		3	
									1												1	
												1	1								2	
									1												1	
									1												1	
	1																	1				
	1																	1				
														1								1
																	1					1
Total	40	6	135	80	28	45	43	29	185	5	6	4	7	4	4	2	3	40	249	117	207	13

[1] These fish were caught by the research vessel *Cape Agulhas*. The general area of capture is shown in a paper by Frost (1938).

of the foregoing information, these fish must been born in 1943 and 1945, respectively. The s began to form in 1944 and 1946, respectively, by March 1945 and 1947, respectively, would the first annular ring. Therefore, in the pres- ge and growth study, the calendar year of birth rosefish is obtained by adding one additional to the total number of annuli shown on the

METHODS OF ANALYSIS

o procedures were followed in estimating the hs of rosefish at past ages from the spacing of the li. In both, a straight line was fitted to the thmic values for fish lengths plotted against radius. In the first use of this line the constant in the logarithmic equation was employed in ng the following formula by means of which ns were computed directly from scale measure- s.

$$Ln = C + \frac{Sn}{S}(L - C)$$

C—is the intercept value at the X axis of a straight line fitting the data.

L—the log of the length of the fish when caught.

Ln—the log of the computed length of the fish at the end of any year.

S—the log of the anterior scale radius of the fish when caught.

Sn—the log of the anterior scale radius to any annulus.

The second method follows the procedure used by Hile (1941) in the study of the age and growth of the rock bass (*Ambloplites rupestris*). Essentially, it involves the solution of the logarithmic equation to build up a table of theoretical scale lengths at different body lengths. Before the measurements for a particular scale can be used for reading the calculated length from the table, each must be adjusted according to the ratio of the theoretical to the actual scale size.

On theoretical grounds the two procedures can give identical results only if before application of the formula (first procedure) the scale measurements are adjusted to the theoretical values in the same manner as that followed by Hile. It is easy to demonstrate that strictly accurate results are obtained from

TABLE 6.—*Comparison of average calculated fish-length values, in millimeters, at each annulus*

[Material collected in Monhegan-Jeffreys-Platts area, October–December 1942]

Calculated from fish born in—	Annulus																		Nu of
	1		2		3		4		5		6		7		8		9		
	A [1]	B [2]	A [1]	B [2]	A [1]	B [2]	A [1]	B [2]	A [1]	B [2]	A [1]	B [2]	A [1]	B [2]	A [1]	B [2]	A [1]	B [2]	
1932	47	47	70	70	98	98	111	112	132	132	149	149	167	166	191	191	204	203	
1933	49	49	72	72	89	88	120	120	144	144	166	166	184	184	200	199	------	------	
1934	44	44	73	72	95	95	119	118	139	139	157	157	175	175	------	------	------	------	
1935	50	50	74	74	97	97	118	118	137	136	158	158	------	------	------	------	------	------	
1936	46	46	79	79	107	107	131	131	154	154	------	------	------	------	------	------	------	------	
1937	51	51	78	78	111	111	131	131	------	------	------	------	------	------	------	------	------	------	
1938	50	50	73	73	105	104	------	------	------	------	------	------	------	------	------	------	------	------	
1939	50	50	91	91	------	------	------	------	------	------	------	------	------	------	------	------	------	------	
1940	57	57	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	
Weighted mean	49	49	76	76	102	102	123	123	141	141	158	158	175	175	196	193	204	203	
Number of fish	70		69		64		53		41		32		13		4		2		

[1] Method 1.—Calculations were based on a straight line fitted to the logarithmic values for fish lengths and scale radii obtained from material collected from Oct December 1942 in the Monhegan-Jeffreys-Platts area; collections 2–5, 71 fish. Scales for 1 fish could not be read because no good scales were on the slide.
[2] Method 2.—Calculations were based on a curve fitted to the arithmetical values for fish lengths and scale radii for the same material analyzed by method

TABLE 7.—*Comparison of average calculated fish-length values, in millimeters, at each annulus*

[Material collected in Mount Desert-Matinicus area, July–September 1943]

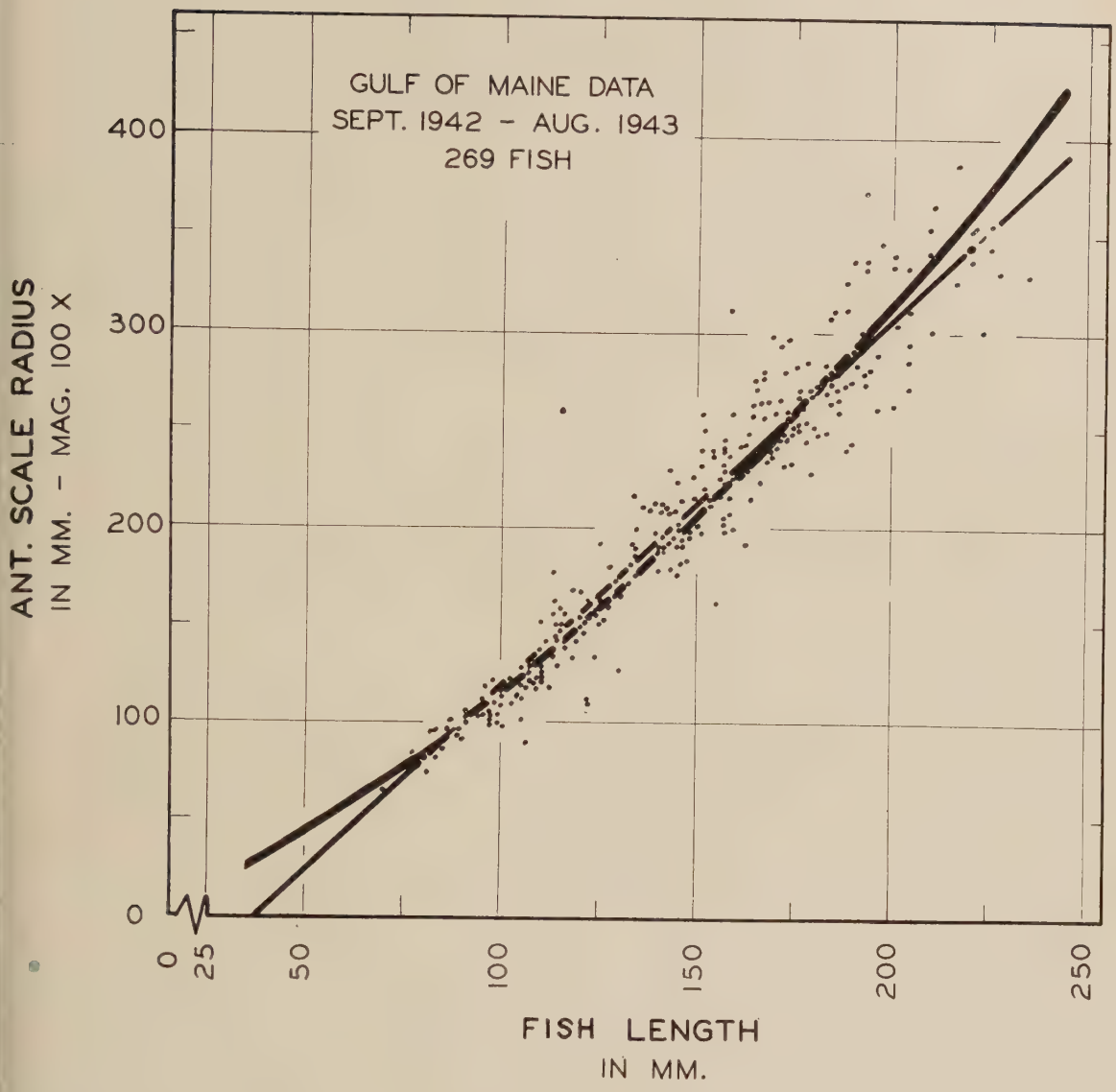
Calculated from fish born in—	Annulus														Nu of
	1		2		3		4		5		6		7		
	A [1]	B [2]	A [1]	B [2]	A [1]	B [2]	A [1]	B [2]	A [1]	B [2]	A [1]	B [2]	A [1]	B [2]	
1935	50	49	60	60	94	93	116	116	131	131	145	145	159	159	
1936	53	54	74	74	90	90	104	104	129	129	144	144	------	------	
1937	55	54	76	76	97	96	113	113	133	133	------	------	------	------	
1938	54	54	73	73	92	92	110	110	------	------	------	------	------	------	
1939	58	58	77	77	96	96	------	------	------	------	------	------	------	------	
1940	60	60	78	79	------	------	------	------	------	------	------	------	------	------	
1941	67	67	------	------	------	------	------	------	------	------	------	------	------	------	
Weighted mean	57	57	76	76	94	94	110	110	132	132	144	144	159	159	
Number of fish	81		77		52		38		15		6		1		

[1] Method 1.—Calculations were based on a straight line fitted to the logarithmic values for fish lengths and scale radii obtained from material collected from September 1943 in the Mount Desert-Matinicus area (collections 13, 14, 16, 17, 18: 84 fish). 3 fish could not be read because no good scales were on the slide.
[2] Method 2.—Calculations were based on a curve fitted to the arithmetical values for fish lengths and scale radii for the same material analyzed by metho

the formula only when the scale measured is of exactly the theoretical length. That the errors arising from deviations of the measured scales from the theoretical values have no important effect on the averages of calculated lengths for groups of fish is demonstrated, however, by the extremely close agreement between the results obtained independently by the two procedures (tables 6 and 7). The discrepencies were few and always no more than a millimeter. For practical purposes either procedure can be followed. The second is preferable, not only because it is easier to follow, but also because it gives accurate calculations for individual fish as well as for group averages.

VARIATIONS IN THE FISH LENGTH-SCALE RADIUS RELATIONSHIP

Since both methods of calculating from scales size at a previous age employ the fish length-s radius relationship, variations in this relation from season to season or from one biological are another would result in different values for estim lengths. A comparison of the slope of the l describing the fish-length and scale-length relat ship at different seasons in various areas was tempted but discontinued because of the s amount of data available for many of these seaso area units. Instead, a more general approach employed.



RE 16.—Relationship in arithmetical terms of the anterior scale radius to the length of rosefish for 269 fish 235 mm. or less, taken he Gulf of Maine from September 1942 through August 1943. Both the straight line and curve were calculated to fit the data. e formula for the straight line is $y = -68.84 + 1.88x$.

amination of the individual collections made in Gulf of Maine from September 1942 through mber 1944 shows three series of collections aining a relatively large number of fish which nto one biological area during a single calendar ter; namely, a series in the Mount Desert-nicus area from October through December [8] in the same area from July through September [9] and in the Monhegan-Jeffreys-Platts area from October through December 1942.[10] The estimated length at each age was calculated independently for each of the three sets of data. The resulting values were then combined and the average calculated lengths at each age obtained (table 8, column A).

At the same time, the fish length-scale radius relationship was determined for all material collected in the Gulf of Maine from September 1942 through August 1943.[11] On the basis of this rela-

[8] lections 19–24: 72 fish; table 2, fig. 5.
[9] lections 13, 14, and 16–18: 84 fish; table 2, fig. 5.

[10] Collections 2–15: 71 fish; table 2, fig. 5.
[11] Collections 1–18: 269 fish; figures 16 and 17.

TABLE 8.—*Comparison of average calculated fish length values, in millimeters, at each annulus computed from lines fitted separately to len scale data for various areas at various time intervals and from a single line fitted to length—scale data*

[Collections made in the Gulf of Maine from September 1942 through August 1943]

Calculated from fish born in—	Annulus																
	1		2		3		4		5		6		7		8		9
	A[1]	B[2]	A[1]	B[2]	A[1]	B[2]	A[1]	B[2]	A[1]	B[2]	A[1]	B[2]	A[1]	B[2]	A[1]	B[2]	A[1]
1932	47	48	74	79	96	104	118	112	137	133	155	146	172	163	189	186	202
1933	49	52	76	75	98	98	122	120	141	141	163	158	182	174	201	192	------
1934	47	51	75	75	99	96	123	116	144	133	164	151	183	167	------	190	------
1935	49	55	73	77	98	99	119	120	139	137	161	157	159	174	------	162	------
1936	49	50	77	76	103	103	124	123	146	145	144	150	------	157	------	------	------
1937	53	52	78	78	104	104	124	125	133	138	------	149	------	------	------	------	------
1938	52	51	73	75	97	100	110	120	------	------	------	------	------	------	------	------	------
1939	56	52	80	76	96	96	------	124	------	------	------	------	------	------	------	------	------
1940	59	54	75	74	------	95	------	------	------	------	------	------	------	------	------	------	------
1941	67	58	------	81	------	------	------	------	------	------	------	------	------	------	------	------	------
1942	------	55	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
Weighted mean	52	52	75	76	99	99	120	121	141	139	161	154	180	169	196	189	202
Number of fish	222	308	218	297	186	251	158	203	116	139	89	90	51	38	23	12	10

[1] Straight lines were fitted independently to logarithmic values for fish lengths and scale radii obtained from material collected in the Mount Desert-Matinicus from July-September 1943 (collections 13, 14, 16, 17, 18; 84 fish); in the same area from October–December 1942 (collections 19–24; 72 fish); in the Monhegan-Jef Platts area from October–December 1942 (collections 2–5; 71 fish). No good scales were available for 1 fish in collection 2, for 1 fish in collection 16, and for 2 f collection 18. The data collected in each area during each 3-month interval was analyzed by method 1 using the corresponding line.

[2] A curve was fitted to the values for fish lengths and scale radii obtained from material collected throughout the Gulf of Maine from September 1942 th August 1942 (collections 1–18; 269 fish). Data collected throughout the Gulf of Maine in 1942 (collections 1, 3, 4, 6; 113 fish) in 1943 (collections 10, 11, and 1 131 fish), and in 1944 (collections 25–39; 65 fish) were analyzed by method 2 using this curve.

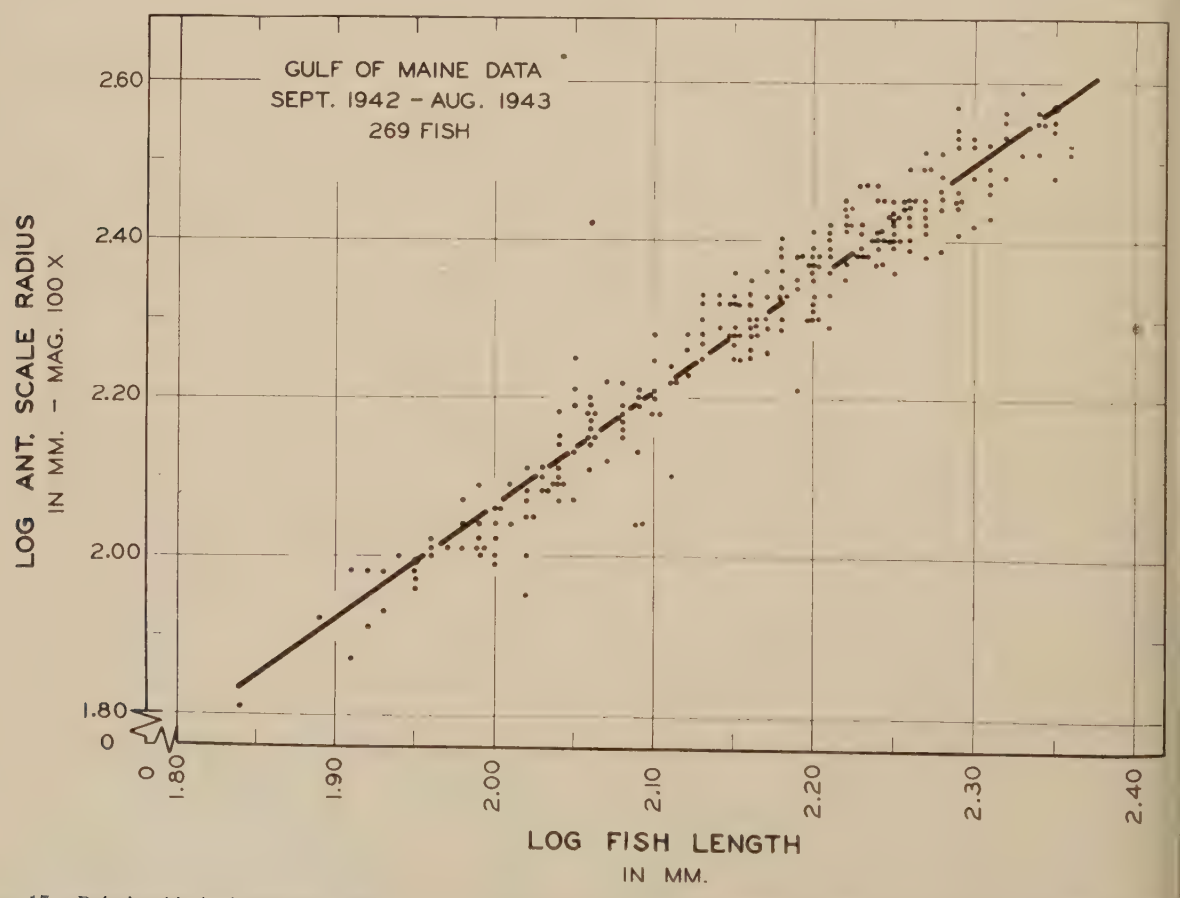
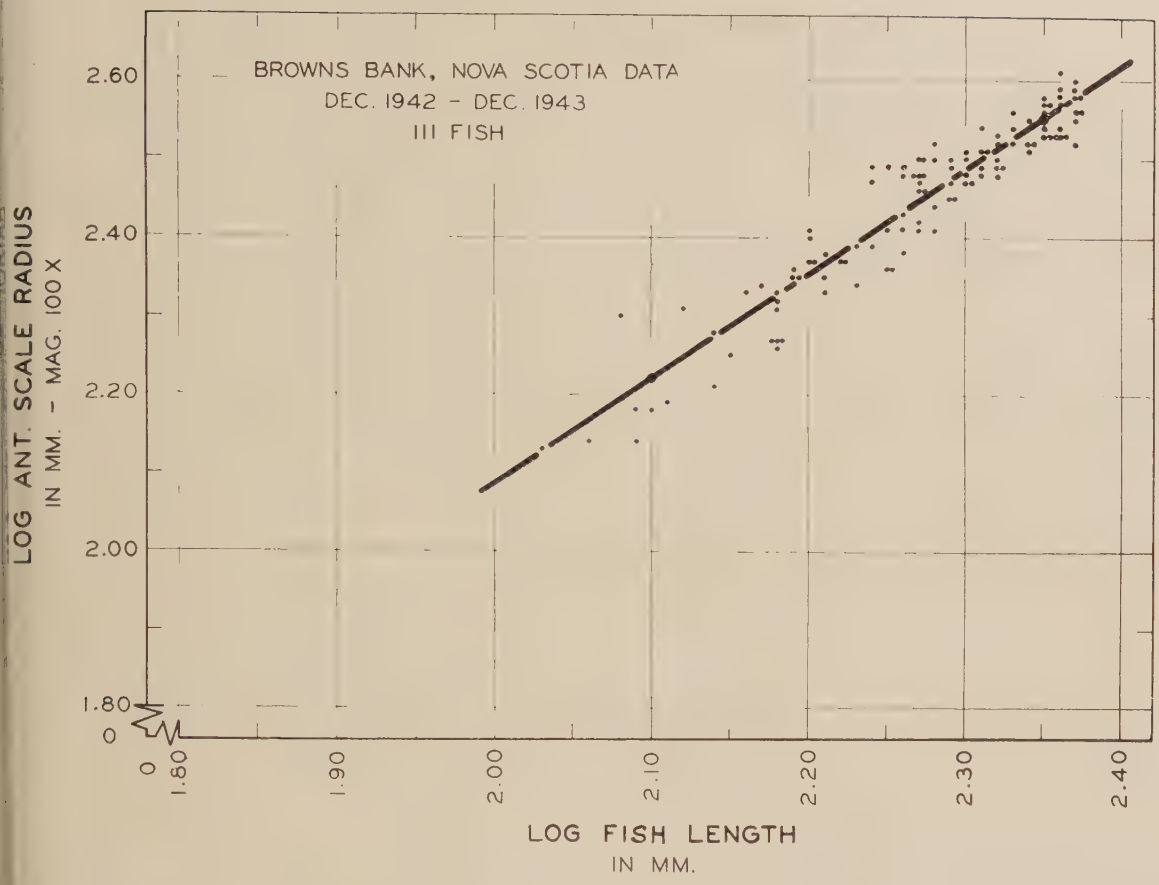


FIGURE 17.—Relationship in logarithmic terms of the anterior scale radius to the length of rosefish for 269 fish 235 mm. or less, t in the Gulf of Maine from September 1942 through August 1943. The straight line was calculated to fit the data. Its form log $y = -.831 + 1.447 \log x$.



E 18.—Relationship of the anterior scale radius to the length of rosefish for 111 fish, 235 mm. or less, taken in the Browns Bank ea of western Nova Scotia from December 1942 through December 1943. The straight line was calculated to fit the data. s formula is log $y = -.596 + 1.340 \log x$.

ip, the estimated age at each annulus was ated for data collected throughout the Gulf aine in 1942,[12] 1943,[13] and in 1944.[14] The ge calculated lengths obtained are shown in 8, column B.

e values for average calculated lengths at each us obtained from computations based on the dual sets of data and the total data are in greement. This would indicate that variation length-scale radius relationship, both seasonal rom one biological area to another, does not y affect the accuracy of calculated length . Therefore, the calculated length values for mbined data were accepted as the best avail- stimates of rosefish length at a given age. rly, the estimated age at each annulus was ated from the fish length-scale radius relation- or all data collected from December 1942 through December 1943 in the Browns Bank area of western Nova Scotia (fig. 18).

RESULTS

CALCULATED LENGTHS AT EACH ANNULUS

The data collected in 1942, 1943, and 1944 were analyzed separately, and the calculated sizes obtained for the 3 years are summarized in table 9. The estimated average length of the fish at each annulus varies at random among the different year classes but the variation is remarkably small. The weighted mean estimated length at each annulus of all the year classes is as follows: annulus 1, 52 mm.; annulus 2, 76 mm.; annulus 3, 99 mm.; annulus 4, 121 mm.; annulus 5, 139 mm.; annulus 6, 154 mm.; annulus 7, 169 mm.; annulus 8, 189 mm.; and annulus 9, 218 mm. (table 10, fig. 19). The estimated average lengths of the rosefish at each annulus in the Browns Bank area of western Nova Scotia are similar to those obtained in the Gulf of

ctions 1, 3, 4, 6; 113 fish.
ctions 10, 11, and 13–18: 131 fish.
ctions 25–39: 65 fish.

TABLE 9.—*Average calculated fish length, in millimeters, at each annulus* [1]

[Calculations [2] based on method 2]

Calculated from fish born in—	Annulus								
	1	2	3	4	5	6	7	8	9
1932 [3]	48	79	104	112	133	146	163	186	195
1933	52	75	98	120	141	158	174	192	218
1934	51	75	96	116	133	151	167	190	----
1935	55	77	99	120	137	157	174	162	----
1936	50	76	103	123	145	150	157	----	----
1937	52	78	104	125	138	149	----	----	----
1938	51	75	100	120	143	----	----	----	----
1939	52	76	96	124	----	----	----	----	----
1940	54	74	95	----	----	----	----	----	----
1941	58	81	----	----	----	----	----	----	----
1942	55	----	----	----	----	----	----	----	----
Weighted mean	52	76	99	121	139	154	169	189	218
Standard deviation	7.92	10.53	14.62	17.37	16.89	16.72	19.47	16.51	----
Number of fish	308	297	251	203	139	90	38	12	3

[1] Includes materials collected in the Gulf of Maine in 1942 (collections 1, 3, 4, 6; 113 fish), in 1943 (collections 10, 11, and 13–18; 131 fish), and in 1944 (collections 25–39; 65 fish). Data combined for the years 1942, 1943, and 1944.

[2] Data collected throughout the Gulf of Maine from September 1942 through August 1943 (collections 1–18; 269 fish) were used in deriving the curve employed in obtaining calculated lengths at each annulus by means of method 2.

[3] Only 1 fish was available, and it has not been included in the statistical calculations.

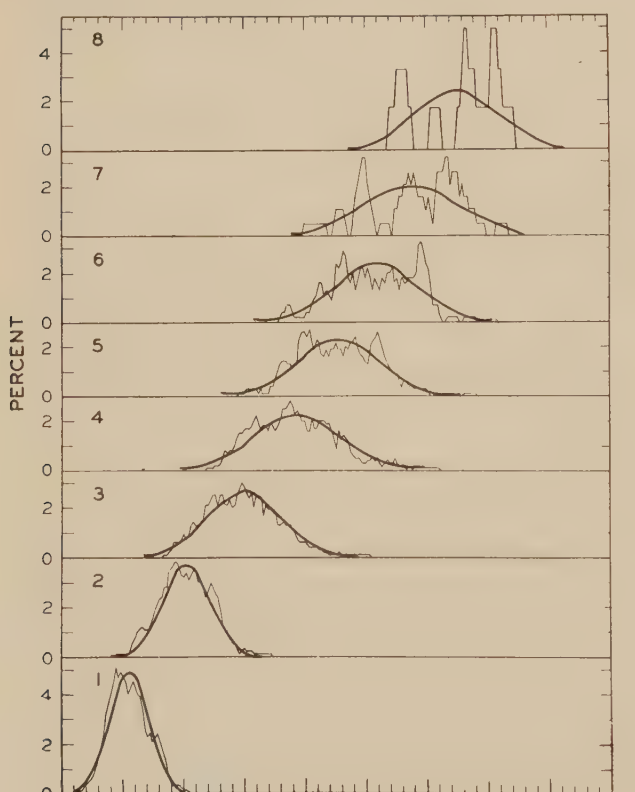


FIGURE 19.—Length-frequency distributions of Gulf of Maine rosefish at each annulus for annuli 1 through 8. Lightly lined irregular curves are the actual frequency distributions smoothed by a moving average of five. Heavily lined smooth curves are normal curves fitted to the actual frequency data.

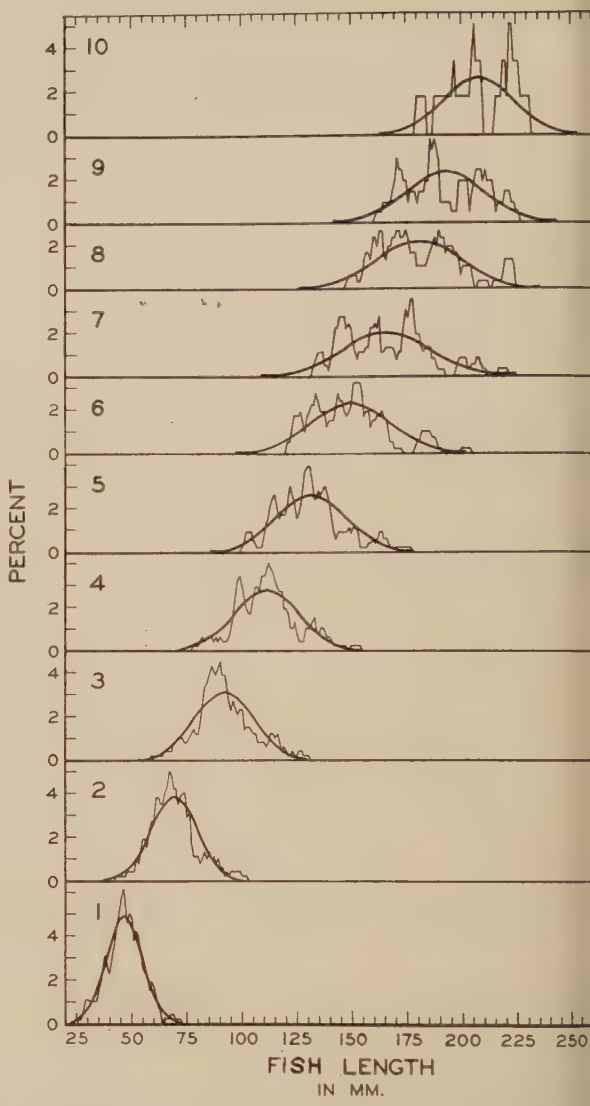


FIGURE 20.—Length-frequency distributions of rosefish from Browns Bank area of western Nova Scotia for each annul annuli 1–10. Lightly drawn irregular curves are the a frequency distributions smoothed by a moving average of Heavily drawn smooth curves are the normal curves fitt the actual frequency data.

Maine. The size at the first annulus is 47 m annulus 2, 69 mm.; annulus 3, 92 mm.; annulu 112 mm.; annulus 5, 132 mm.; annulus 6, 150 m annulus 7, 167 mm.; annulus 8, 181 mm.; annulu 193 mm.; annulus 10, 208 mm. (table 11, fig. 20

COMPARISON OF THE ACTUAL AND CALCULA AVERAGE LENGTH AT ANNULUS 1

The accuracy of the calculated average lengt rosefish at annulus 1 is indicated by a compar with the actual average length of a series of

TABLE 10.—*Calculated fish length, in millimeters, at each annulus to the ninth annulus of rosefish taken in the Gulf of Maine*

[Calculations [1] based on method 2]

Fish length, in millimeters	Annulus								
	1	2	3	4	5	6	7	8	9
	1								
	10								
	36								
	78	1							
	62	2							
	60	16							
	33	22							
	23	42	1						
	5	56	8						
		46	10						
		45	18						
		41	32	1					
		17	28	8					
		4	32	13					
		3	30	17	2				
		2	30	17	2				
			24	18	3				
			17	25	10	2			
			9	24	10	1			
			5	16	19	2	1		
			4	20	12	7	1		
			1	13	13	6	1		
			1	13	14	12	1		
			1	5	13	8	4		
				4	14	8	3		
				2	13	8	1		
				5	6	7	2	1	
					4	7	4	2	
				1	2	14	3		
				1		6	2	1	
					1		5		
						1	5		
					1	1	3	3	
							1	1	
								3	1
							1	1	
									1
									1
Total number of fish	308	297	251	203	139	90	38	12	3
Standard deviation	7.9	10.5	14.6	17.4	16.9	16.7	19.5	16.5	

[1] Calculations were based on a curve fitted to the values for fish lengths and scale radii obtained from material collected throughout the Gulf of Maine from September 1942 through August 1943 (collections 1–18; 269 fish). Data collected throughout the Gulf of Maine in 1942 (collections 1, 3, 4, 6; 113 fish); in 1943 (collections 11, and 13–18; 131 fish); and in 1944 (collections 25–39; 65 fish) were analyzed using this curve. 1 fish born in 1932 is not included in the above data.

ng one annulus on their scales. Sixty-one hens, the total catch of rosefish taken incidenby a shrimp trawler fishing in the Monhegan-ys-Platts area in March 1947, ranged in size 46 to 63 mm. and averaged 56 mm. in length. from 12 of these fish taken at random had 1 us, with 2 of the 12 showing initial growth d the second annulus. The calculated length efish at annulus 1 in the Gulf of Maine has stablished as 52 mm. which is in close agreewith the 56-mm. length obtained above.

GROWTH BETWEEN ANNULI

rate of growth of rosefish from the Gulf of and off the Browns Bank area of western Scotia was computed by averaging the differences between the calculated lengths of individual fish at each annulus. For the Gulf of Maine data, the growth rate between annuli of individual year classes was determined separately (table 12). The average growth between annuli shows little variation within year classes. The average rate of growth for all year classes to annulus 1 is 52 mm.; between annulus 1 and 2, 24 mm.; 2 and 3, 24 mm.; 3 and 4, 22 mm.; 4 and 5, 19 mm.; 5 and 6, 19 mm.; and between 6 and 7, 7 and 8, 8 and 9, 16 mm. (table 13, fig. 21).

In the Browns Bank area of western Nova Scotia, the average growth to annulus 1 is 47 mm.; between annulus 1 and 2, 22 mm.; annulus 2 and 3, 23 mm.; annulus 3 and 4, 21 mm.; 4 and 5, 20 mm.; 5 and 6, 19 mm.; between 6 and 7, 7 and 8, 8 and 9, 17 mm.; and between 9 and 10, 16 mm. (table 14, fig. 21).

TABLE 11.—*Calculated fish length, in millimeters, at each annulus to the eleventh annulus of rosefish taken in the Browns Bank area of we Nova Scotia*

[Calculations [1] based on method 1]

Fish length, in millimeters	Annulus										
	1	2	3	4	5	6	7	8	9	10	
25–29	1										
30–34	5										
35–39	13										
40–44	18										
45–49	28	1									
50–54	22	5									
55–59	11	8									
60–64	4	20	1								
65–69	1	26	2								
70–74	1	20	5								
75–79		9	6								
80–84		5	13	3							
85–89		6	21	2							
90–94		1	20	2							
95–99		2	12	12							
100–104		1	8	9	4						
105–109			4	14	1						
110–114			4	19	7						
115–119			4	13	7						
120–124			1	5	14	2					
125–129			2	2	10	8					
130–134				6	15	9					
135–139				5	13	8	4				
140–144				1	4	6	5				
145–149				1	4	8	10				
150–154				1	5	13	4	2			
155–159					1	8	5	5			
160–164					3	7	8	6	1		
165–169					2	4	5	6	2		
170–174					1	1	4	8	5		
175–179					1		13	5	3		
180–184						4	5	3	3	1	
185–189						3	3	6	7		
190–194							1	7	2	1	
195–199								5	1	2	
200–204						1	3	3	4	1	
205–209							3		5	2	
210–214								1	4		
215–219							1	1	2	1	
220–224								4	3	3	
225–229										1	
230–234											
Total number of fish	104	104	103	95	92	82	74	62	42	12	
Mean	47	69	92	112	132	150	167	181	193	208	
Standard deviation	8.2	10.4	12.9	14.1	15.5	17.3	19.5	18.6	17.0	15.0	

[1] Based on a straight line fitted to the logarithmic values for fish lengths and scale radii obtained from material collected from December 1942 through Dec 1943 in the Browns Bank area (collections 40–48; 111 fish). 7 fish could not be read because no good scales were available.

TABLE 12.—*Average calculated growth, in millimeters, between annuli of rosefish captured in the Gulf of Maine* [1]

[Calculations [2] based on method 2]

Growth in year [3]	Annulus								
	0–1 [4]	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9
	48	31	25	8	21	13	17	23	9
	52	23	23	22	21	17	16	18	16
	51	24	21	20	17	18	16	15	
	55	22	22	21	18	20	15	12	
	50	26	26	21	22	19	14		
	52	26	26	21	20	16			
	51	24	25	22	22				
	52	24	22	28					
	54	21	28						
	58	26							
	55								
ed mean	52	23	24	22	19	19	16	16	16
d deviation	7.92	8.91	8.79	7.24	6.01	6.01	4.42	6.78	
of fish used	308	297	251	203	139	90	38	12	3

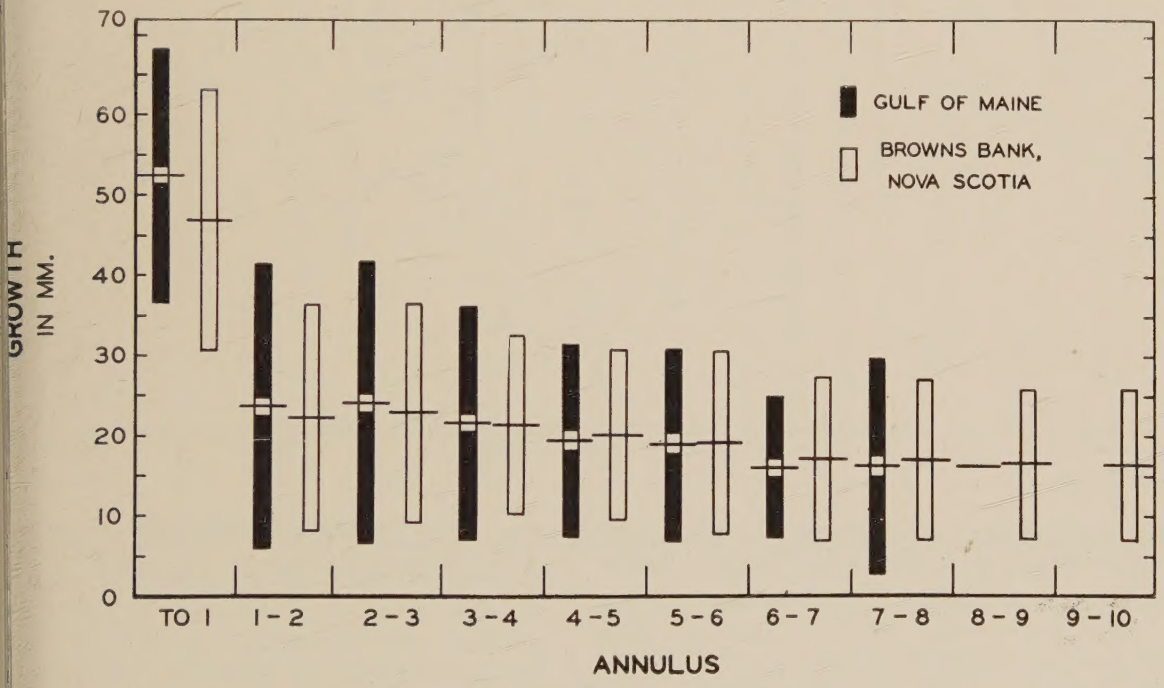
ncludes materials collected in 1942 (collections 1, 3, 4, 6: 113 fish); in 1943 (collections 10, 11, and 13–18: 131 fish); and in 1944 (collections 25–39: 65 fish). Data d for years 1942, 1943, and 1944.

ata collected throughout the Gulf of Maine from September 1942 through August 1943 (collections 1–18: 269 fish) were used in deriving the curve employed in g calculated lengths at each annulus by means of method 2.

xtends from April of the indicated year through March of the following year, as shown by the study of time of annular band formation.

his includes the size at birth, growth until scale formation, and subsequent growth until the completion of the first annulus. Spawning occurs from mid-May early September, and scales are formed in the following year. The first annular ring forms in the second year after the birth of the fish.

nly 1 fish was available, and it has not been included in the statistical calculations.



. 21.—Growth, in millimeters, between annuli of immature rosefish taken in the Gulf of Maine and off the Browns Bank area of ern Nova Scotia. The horizontal lines represent the average growth to each annulus and the vertical bars two standard deviations e and below the mean.

TABLE 13.—*Calculated growth, in millimeters, per annulus to the ninth annulus of rosefish taken in the Gulf of Maine*

[Calculations [1] based on method 2]

Growth to first annulus		Growth between annuli								
Millimeters	Number of fish	Millimeters	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–
			Number of fish							
34	1	5								
35		6		1						
36	3	7			1		3	2		
37	2	8	1	1	2	2	1			
38	2	9	3	1	3	1	2		1	
39	3	10	4	1		3	1	2	2	
40	3	11	9	1	4	6	1			
41	8	12	12	3	2	6	2	1	1	
42	8	13	11	9	10	7	4	3	1	
43	7	14	8	10	13	6	5	5	2	
44	10	15	17	9	7	7	9	6		
45	16	16	10	17	10	8	4	6	1	
46	14	17	5	11	13	12	11	2	1	
47	15	18	15	13	13	5	7	2		
48	14	19	9	15	19	10	2	4		
49	19	20	11	8	8	8	5	1		
50	11	21	14	15	13	13	3			
51	16	22	16	15	7	5	7			
52	13	23	14	13	2	8	5	1		
53	10	24	14	7	7	8	2		1	
54	12	25	13	9	6	4	4	1		
55	15	26	9	8	9	5	1	1		
56	19	27	9	7	11	2	3			
57	11	28	3	2	10	3	1		2	
58	5	29	15	7	3	3	1	1		
59	10	30	7	4	2	1	1			
60	7	31	11	11	3	1	3			
61	6	32	7	5	4	1				
62	8	33	7	9	2		2			
63	6	34	3	7	6	1				
64	6	35	6	1	4	1				
65	8	36	4	5	2	1				
66	9	37	9	2	3					
67	4	38	2	2	3					
68	1	39	4			1				
69	1	40	5	5	1					
70		41	2	5						
71	2	42	2	2						
72	1	43		4						
73	1	44	1	3						
74	1	45								
75		46	1							
76		47		1						
77		48	2	1						
78		49								
79		50		1						
80		51	1							
81		52								
82		53								
83		54								
84		55	1							
Total number of fish	308		297	251	203	139	90	38	12	
Mean	52.42		23.72	24.15	21.62	19.40	18.86	16.05	16.25	16.
Standard deviation	7.92		8.91	8.79	7.24	6.01	6.01	4.42	6.76	

[1] Based on a curve fitted to the values for fish lengths and scale radii obtained from material collected throughout the Gulf of Maine from September 1942 th August 1943 (collections 1–18; 269 fish). Data collected throughout the Gulf of Maine in 1942 (collections 1, 3, 4, 6; 113 fish); in 1943 (collections 10, 11, and 131 fish); and in 1944 (collections 25–39; 65 fish) were analyzed using this curve. 1 fish born in 1932 has not been included in the above analysis.

14.—*Calculated growth, in millimeters, per annulus to the eleventh annulus of rosefish taken in the Browns Bank area of western Nova Scotia*

[Calculations [1] based on method 1]

Growth to first annulus		Growth between annuli										
Millimeters	Number of fish	Millimeters	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11
			Number of fish									
	1	5						1				
		6										
	2	7						1			1	
	3	8					1		1	1		
		9	1			1	1	1				
		10	1			1		5	2	3		
		11		2		3	2	3	5	3	1	
	2	12	3	3	1	2	6	1	5	3		
	3	13	3	2	4	1	2	5	7	1	1	
	3	14	6	3	3	5	6	7	5	5	1	
	2	15	4	3	8	5	6	5	4	4		
	3	16	6	4	5	7	8	3	3	3	1	
	5	17	6	9	7	8	8	6	1	2	1	
		18	4	4	7	4	5	8	3	2	3	
	2	19	6	6	6	8	6	6	6	3	1	
	5	20	6	7	3	6	4	10	6	4		
	6	21	7	4	6	5	1			1	1	
	9	22	7	8	5	6	5	3	5	1		1
	3	23	5	6	8	7	5	2	2	2		
	6	24	3	5	7	2		1	3			
	8	25	3	4	2	5		1		4	1	
	2	26	3	4	7	3	2	1	3			
	5	27	6	2	2		2	2				
	5	28	4	3	3	7	5					
	5	29	5	4	2	1	5					
	3	30	2	2		4		1				
	4	31	3	5	3		1					
	4	32	5	4	1	1			1			
	1	33		1	4		1	1				
	1	34	1	1								
	2	35		1								
	3	36		3	1							
	1	37		1								
	3	38	1									
		39		2								
		40										
		41	1									
		42	1									
		43										
	1	44										
		45	1									
	1											
Number of fish	104		104	103	95	92	82	74	62	42	12	1
Mean	46.91		22.26	22.89	21.41	20.13	19.07	17.11	17.02	16.52	16.42	22.00
Standard deviation	8.15		7.06	6.80	5.62	5.33	5.75	5.15	5.05	4.69	4.72	

[1] Based on a straight line fitted to the logarithmic values for fish lengths and scale radii obtained from material collected from December 1942 through December 1944 (sections 40–48; 111 fish). The scales from 7 fish could not be read because no good scales were available).

CONCLUSIONS

Compared with other North Atlantic species of commercial importance such as haddock, cod, and flounder, the rosefish is extremely slow growing, showing less than a 25-mm. increase in length per year from the 5th to the ninth annulus in both the Gulf of St. Lawrence and off the Browns Bank area of western Nova Scotia. Since these results were obtained for primarily immature fish, it is to be expected that the mature fish will have a slower rate of growth. Marketable rosefish, those 200 mm. in length or greater, are mostly more than 10 years of age, and a superficial examination of the scales of the larger fish indicate that many must be 20 or more years old. A comparable slow rate of growth is reported for rosefish in the Barents Sea. Veschezerov (1941) presents data which show an average growth of 27.8 mm. per annulus to the ninth annulus for fish in that region.

LITERATURE CITED

Bigelow, Henry B., and William W. Welsh.
1925. Fishes of the Gulf of Maine. Bulletin, Bureau of Fisheries, U. S. Dept. Commerce, Vol. XL (1924), Pt. 1: 567. Washington.

Frost, Nancy.
1938. Some fishes of Newfoundland waters (with notes on the distribution of eggs and larvae). Newfoundland Department of Natural Resources, Res. Bull. No. 4: 16.

Graham, Michael.
1929. Studies of age-determination in fish. Part II. A survey of the literature. Ministry of Agriculture and Fisheries, Fishery Investigations, Series II, Vol. XI, No. 3: 50.

Hile, Ralph.
1941. Age and growth of the rock bass, *Ambloplites rupestris* (Rafinesque), in Nebish Lake, Wisconsin. Trans. Wisc Academy of Sciences, Arts and Letters, Vol. 33: 189–3

Van Oosten, John.
1929. Life history of the lake herring (*Leucichthys* Le Sueur) of Lake Huron as revealed by its scales, w critique of the scale method. Bulletin, Bureau of Fish U. S. Dept. Commerce, Vol. XLIV (1928): 265–428. W ington.

Van Oosten, John, H. J. Deason, and Frank W. Jobes.
1934. A microprojection machine designed for the stu fish scales. Journal du Conseil, Vol. IX, No. 2: 241–2

Veschezerov, V. V.
1944. Materials on the biology and fisheries of marine in the Barents Sea [in Russian]. The Knipovich Scientific Institute of Sea-Fisheries and Oceanogr No. 8: 236–270.